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(54) **FUEL SUPPLY SYSTEMS**

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F16K 31/12 (2006.01)

(52) **U.S. Cl.** **123/458**; 137/510; 137/505.14

(58) **Field of Classification Search** 123/457–465; 137/494, 509, 510, 505, 505.12, 505.14
See application file for complete search history.

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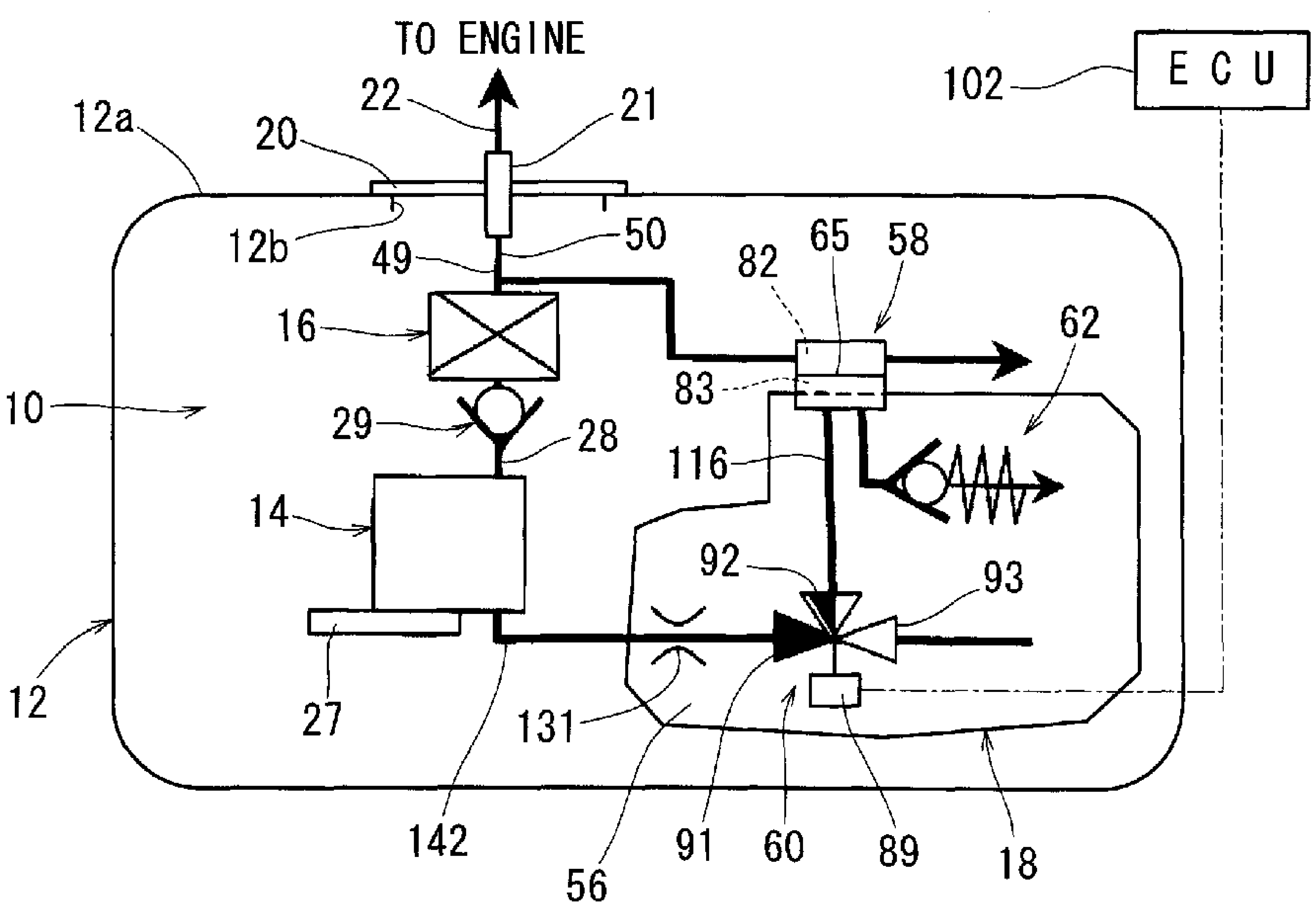
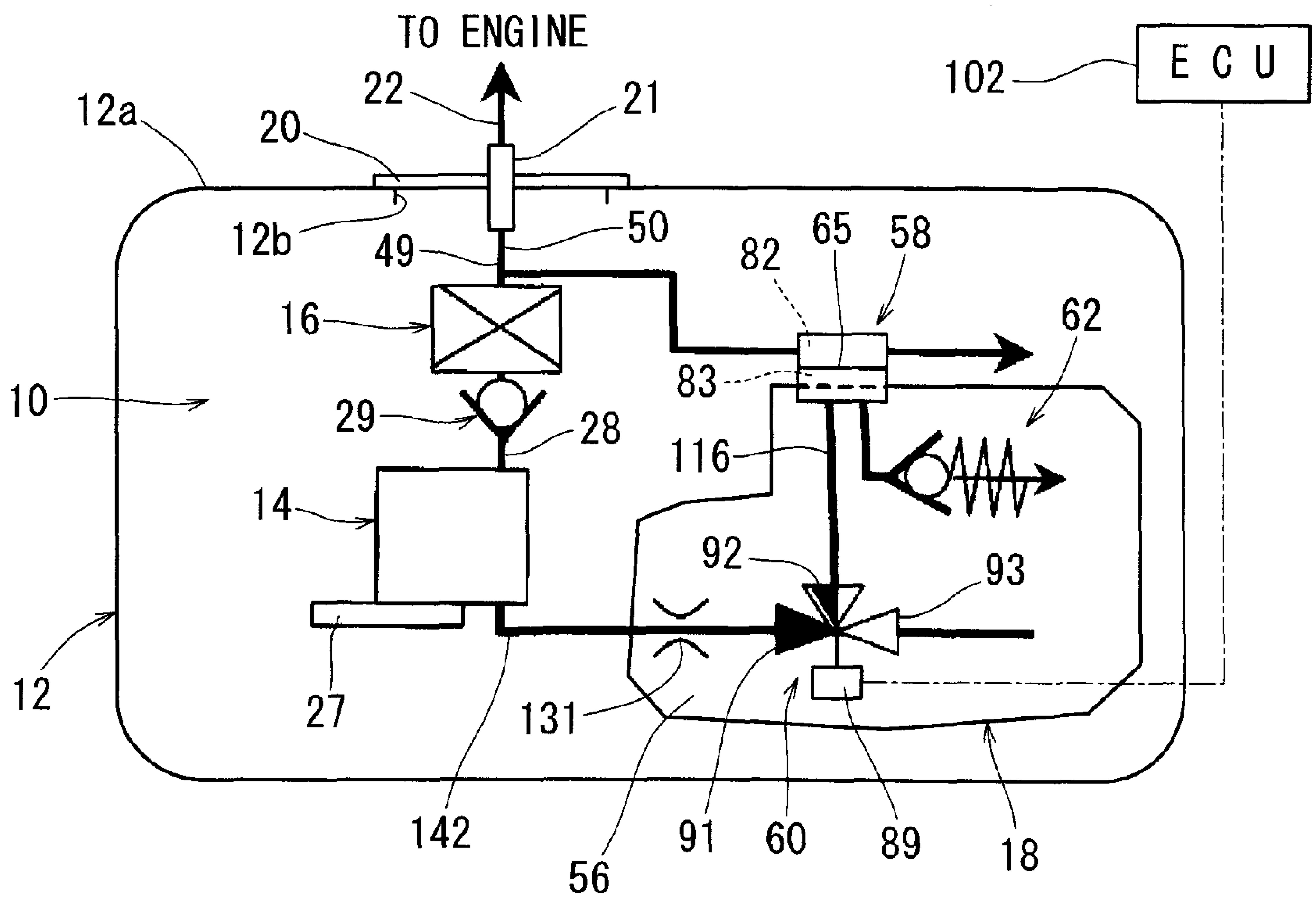
(57) **ABSTRACT**

A fuel supply system includes a fuel pump for supplying fuel in a fuel tank to an engine, a pressure regulator and a three-way valve disposed in a valve chamber. The pressure regulator includes a pressure regulating chamber and a control pressure chamber and adjusts a fuel pressure in the pressure regulating chamber depending on a fuel pressure in the control pressure chamber. A control pressure passage for flowing the fuel to the control pressure chamber and the valve chamber is formed in a unit case.

6 Claims, 11 Drawing Sheets

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12b
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82
65
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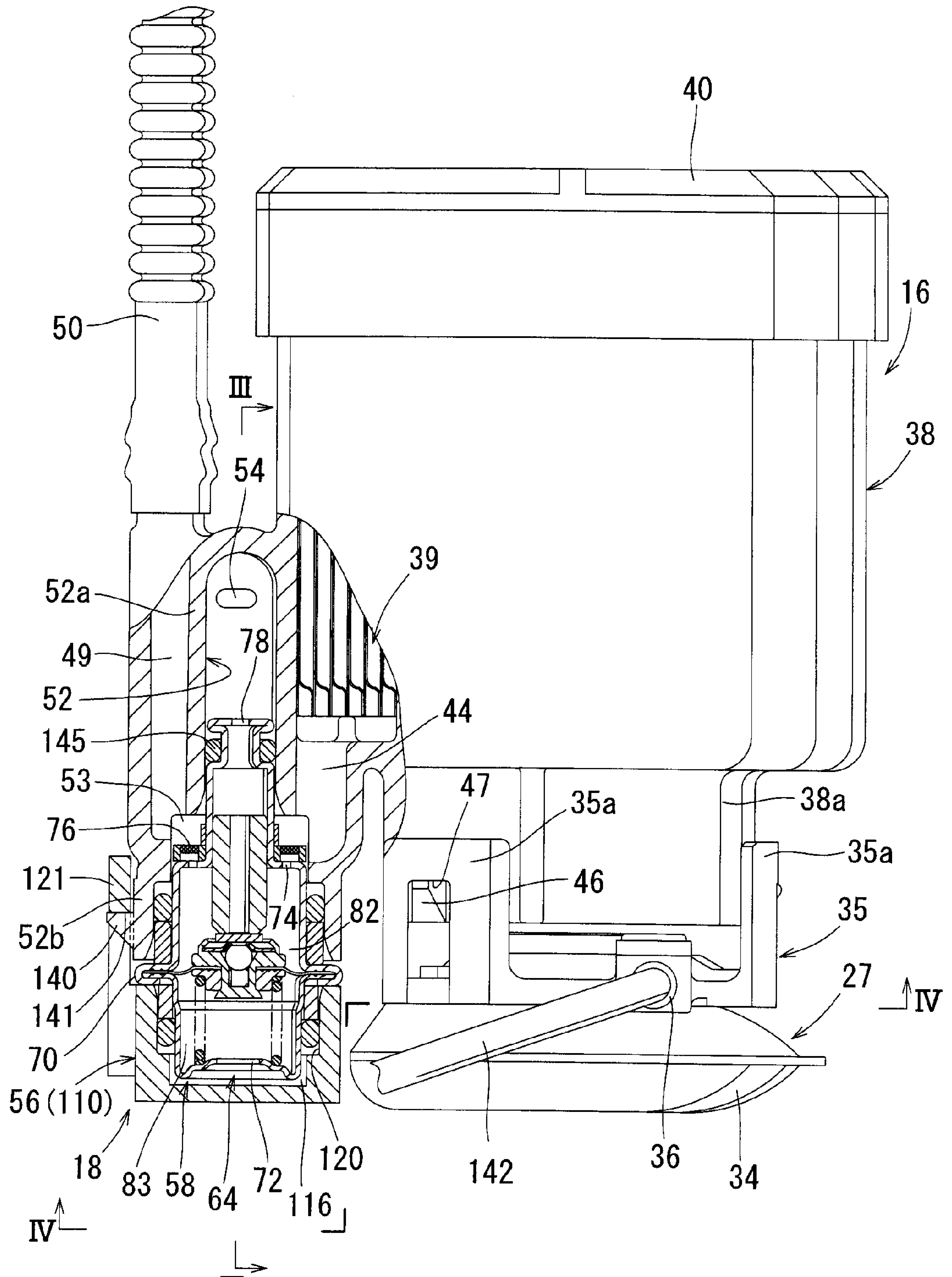
18

FIG. 1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III
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46
52b
74
82
35
140
27
IV
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56(110)
18
83
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64
72
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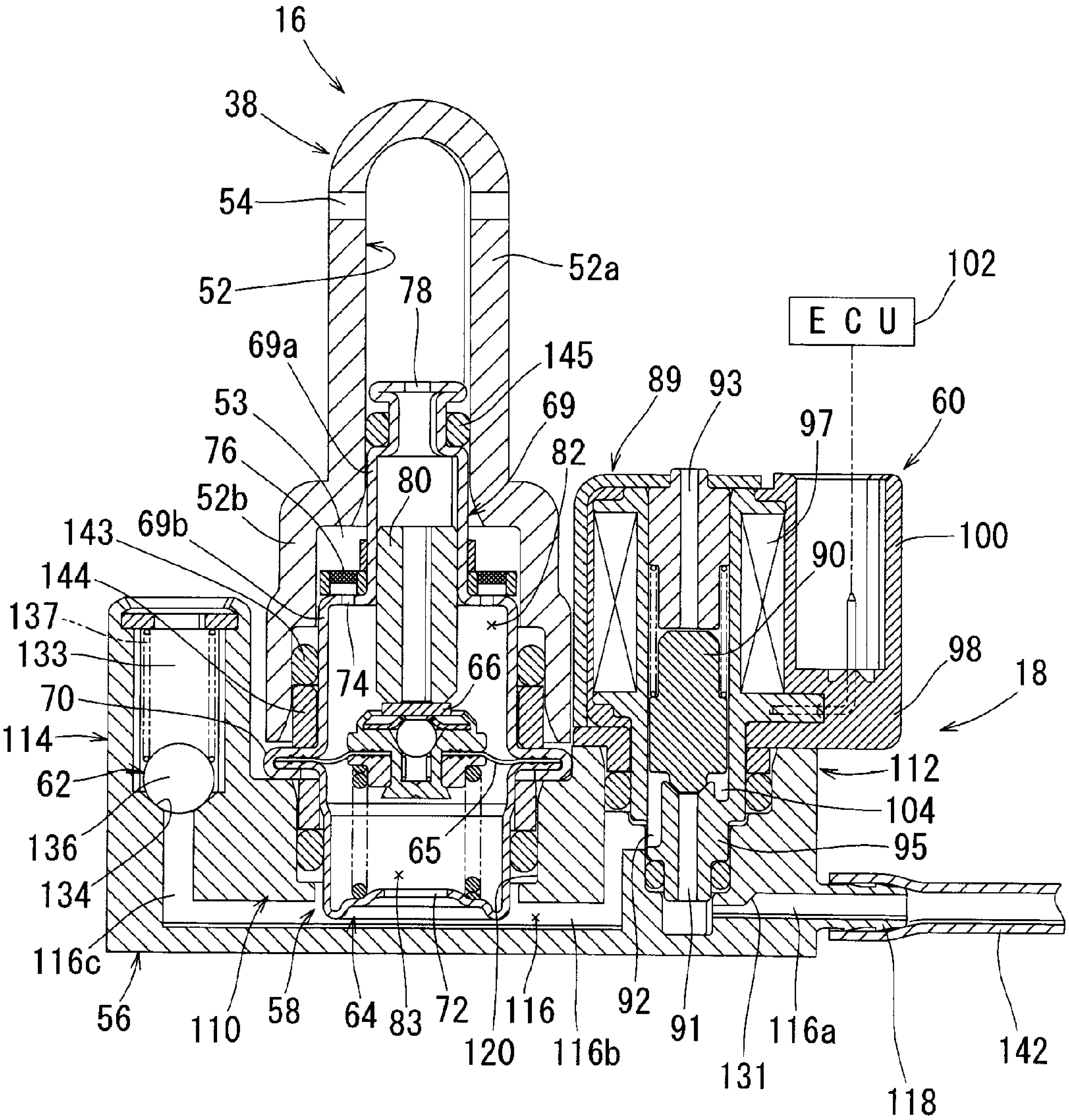
142
36
34
IV
III

FIG. 2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100
143
69b
90
144
137
133
74
66
98
18
70
114
112
62
104
136
65
95
134
116c
56
110
58
64
83
72
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116
116b
92
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131
116a
118
142

FIG. 3

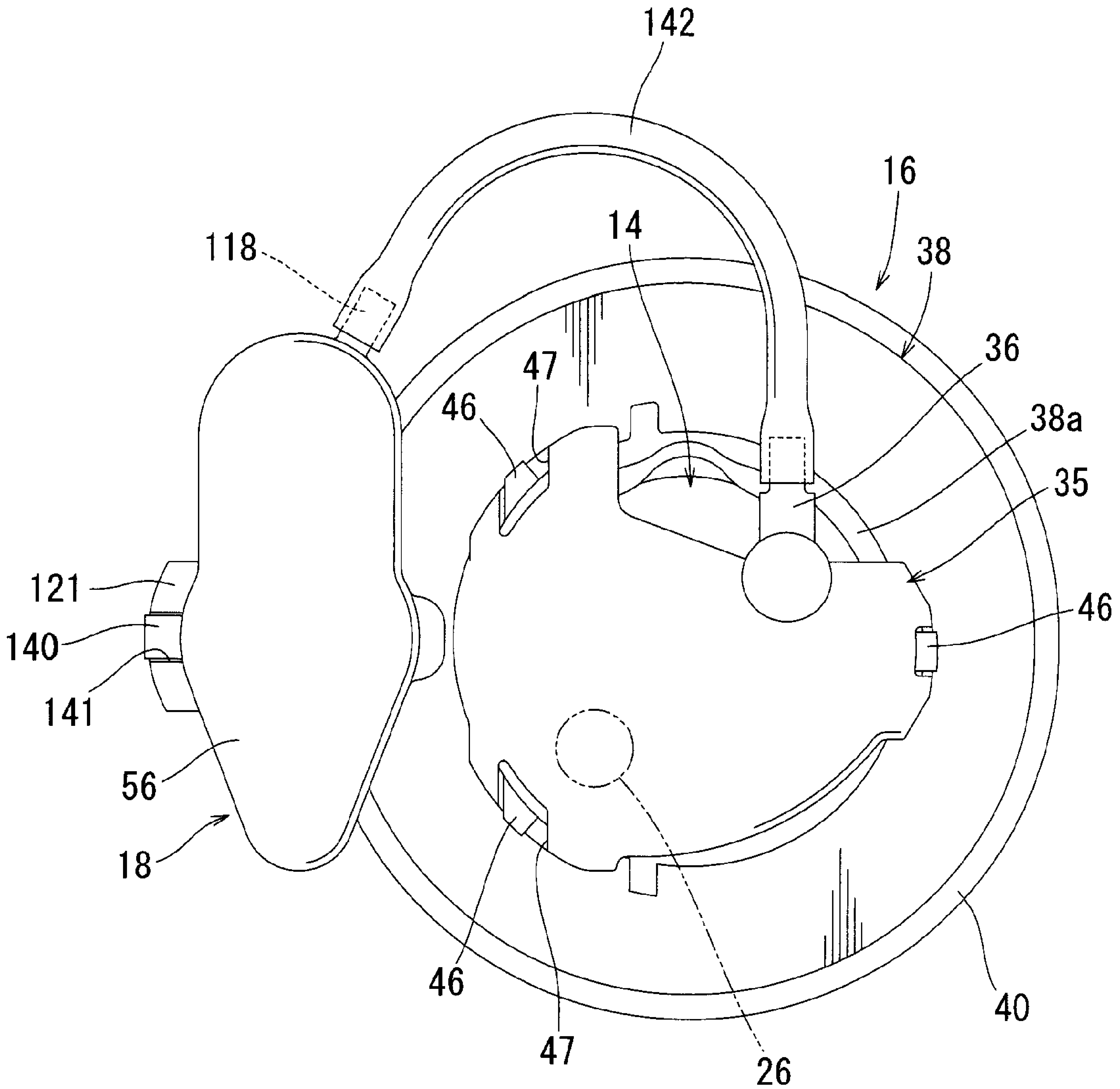
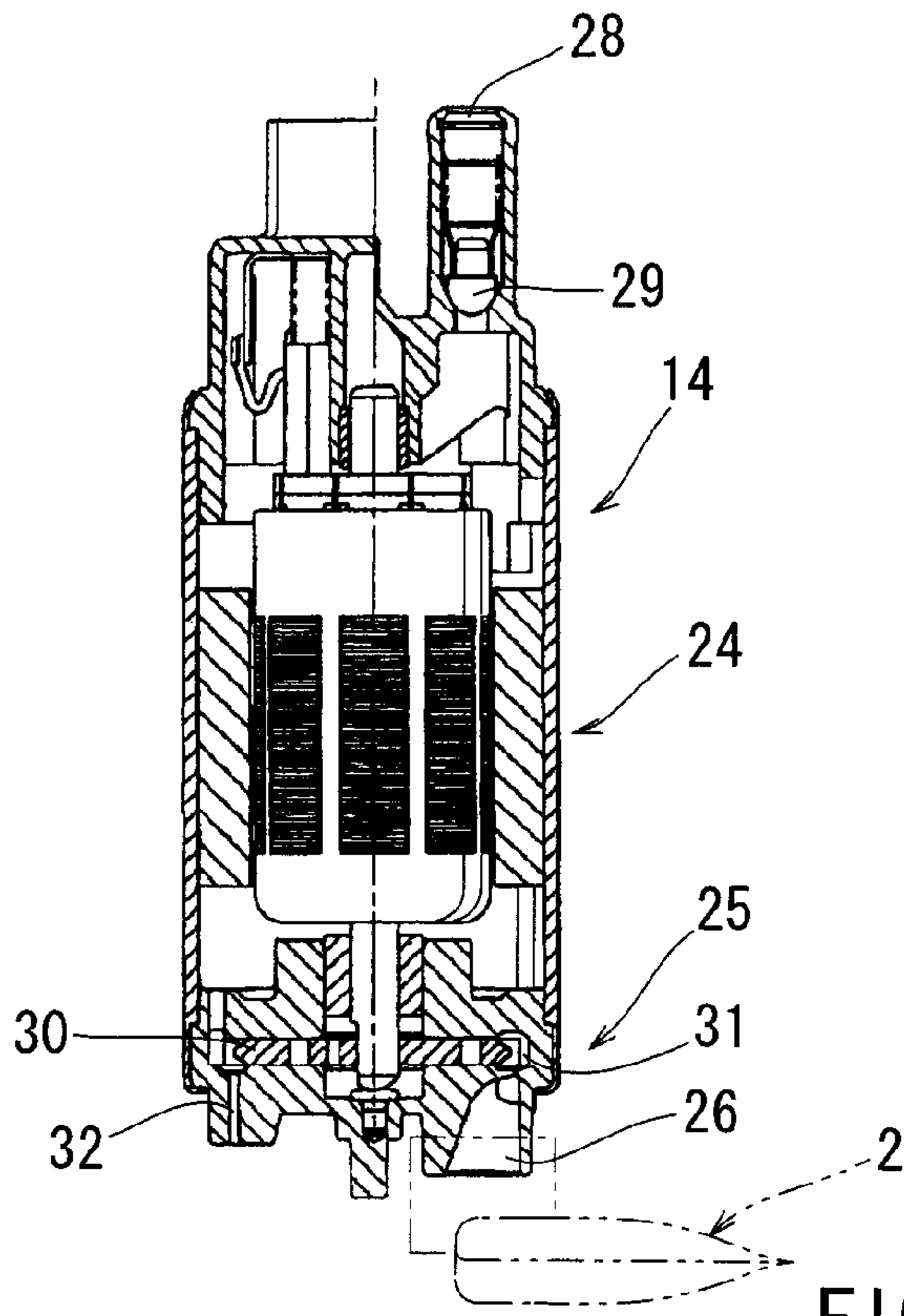


FIG. 4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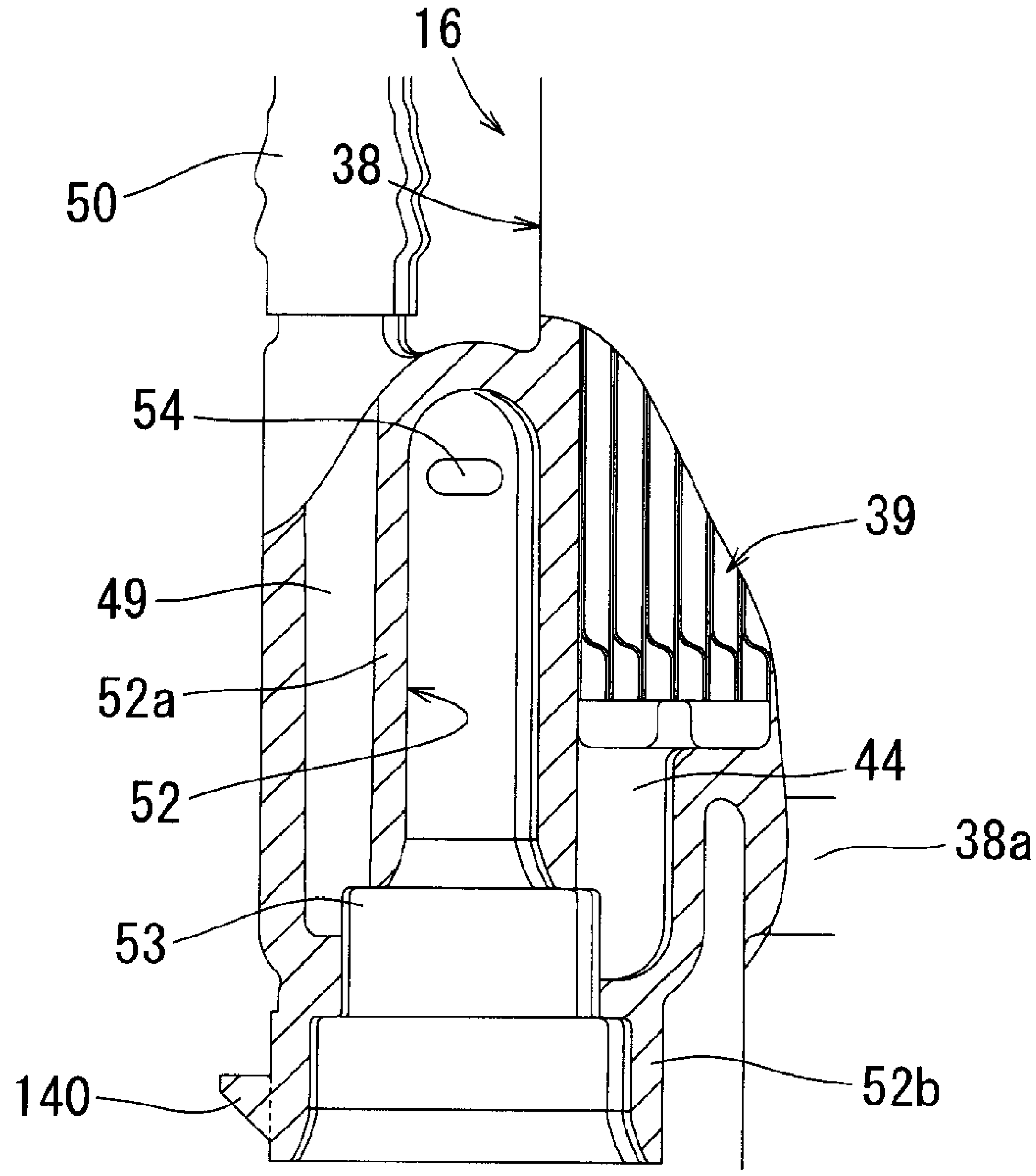
27

FIG. 5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49
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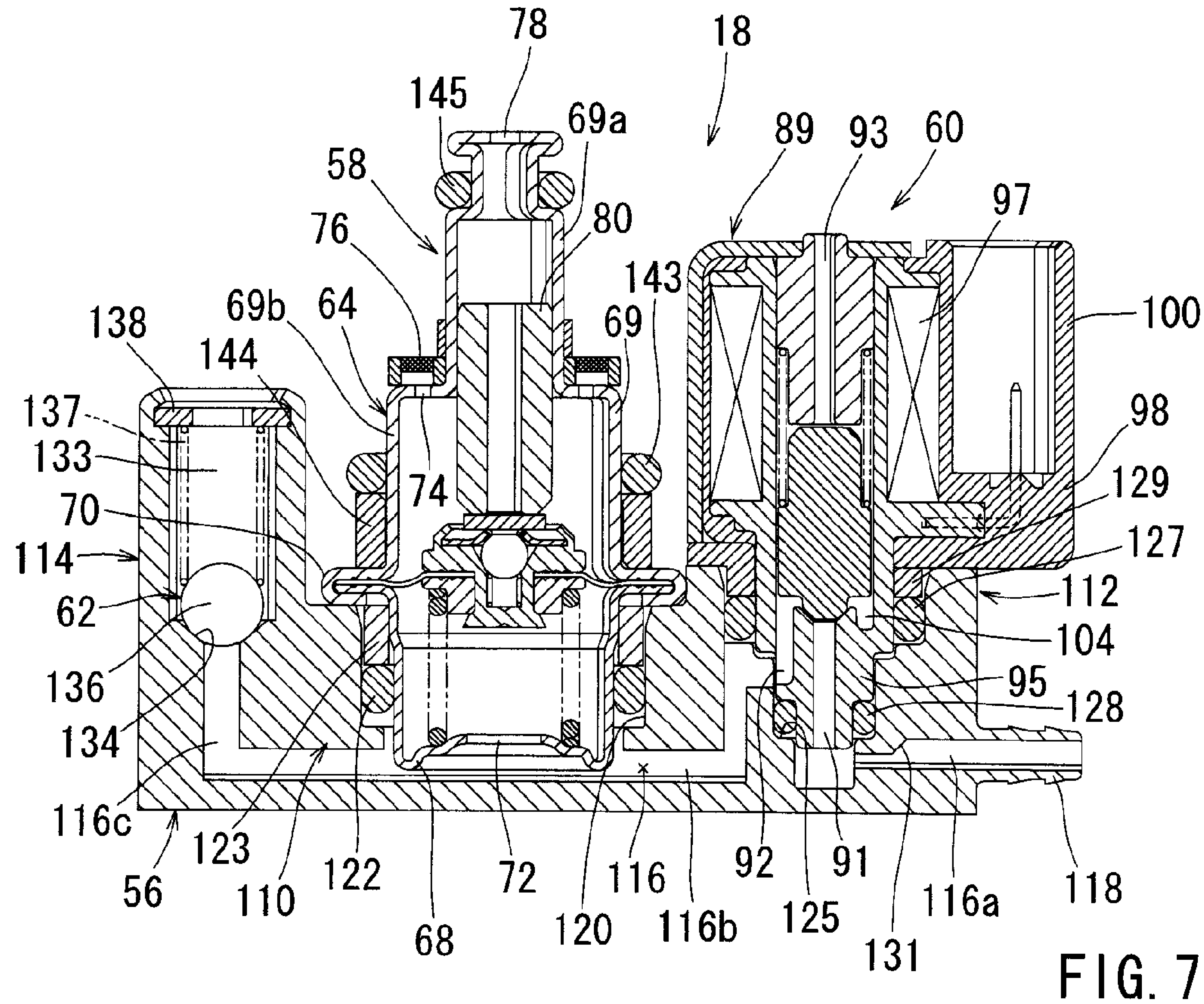
38a
53
140
52b

FIG. 6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69b
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98
70
129
114
127
112
62
104
136
95
128
134
116c
123
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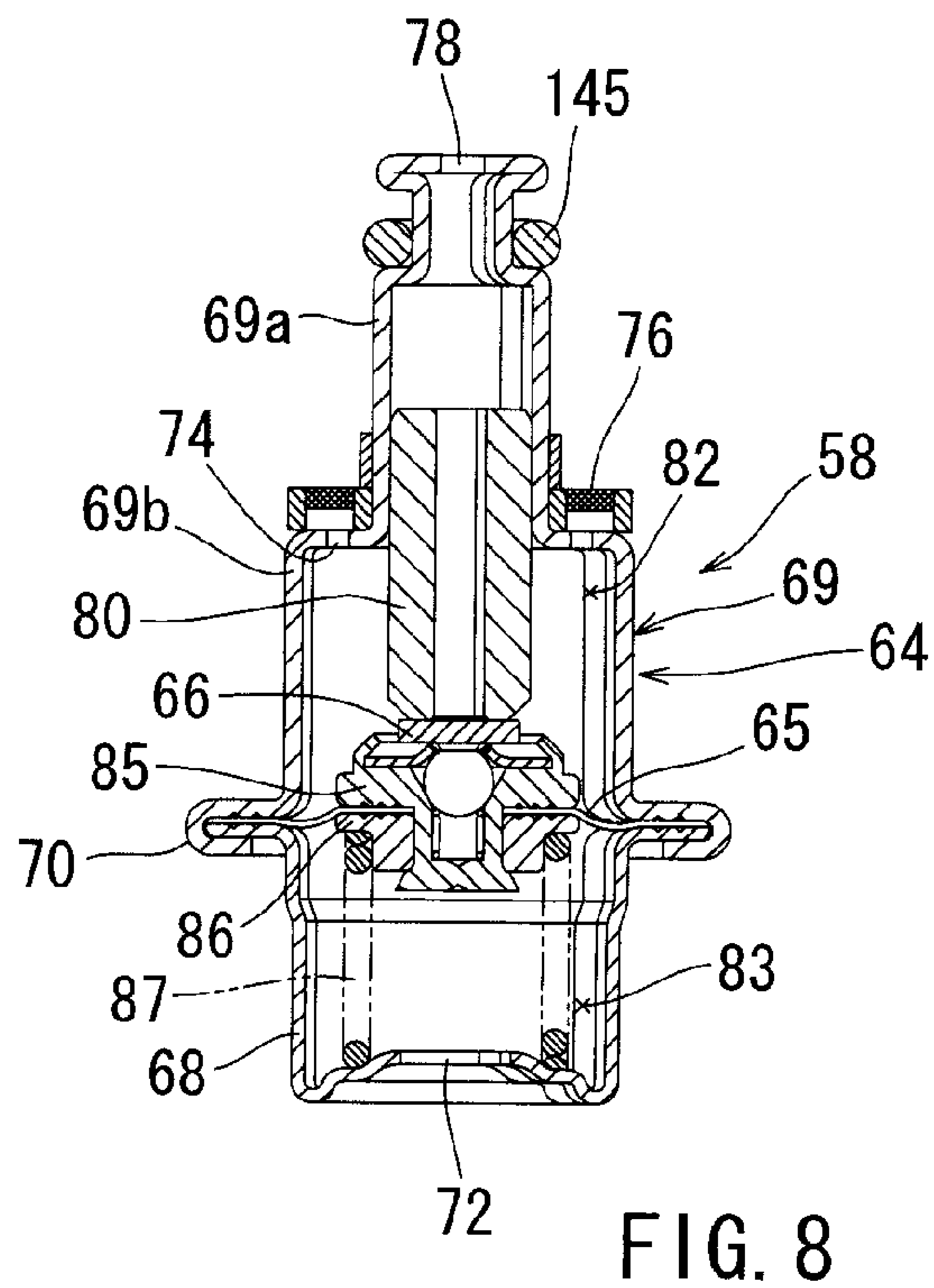
122
72
116
92
91
56
68
120
116b
125
131
116a
118

FIG. 7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72

FIG. 8

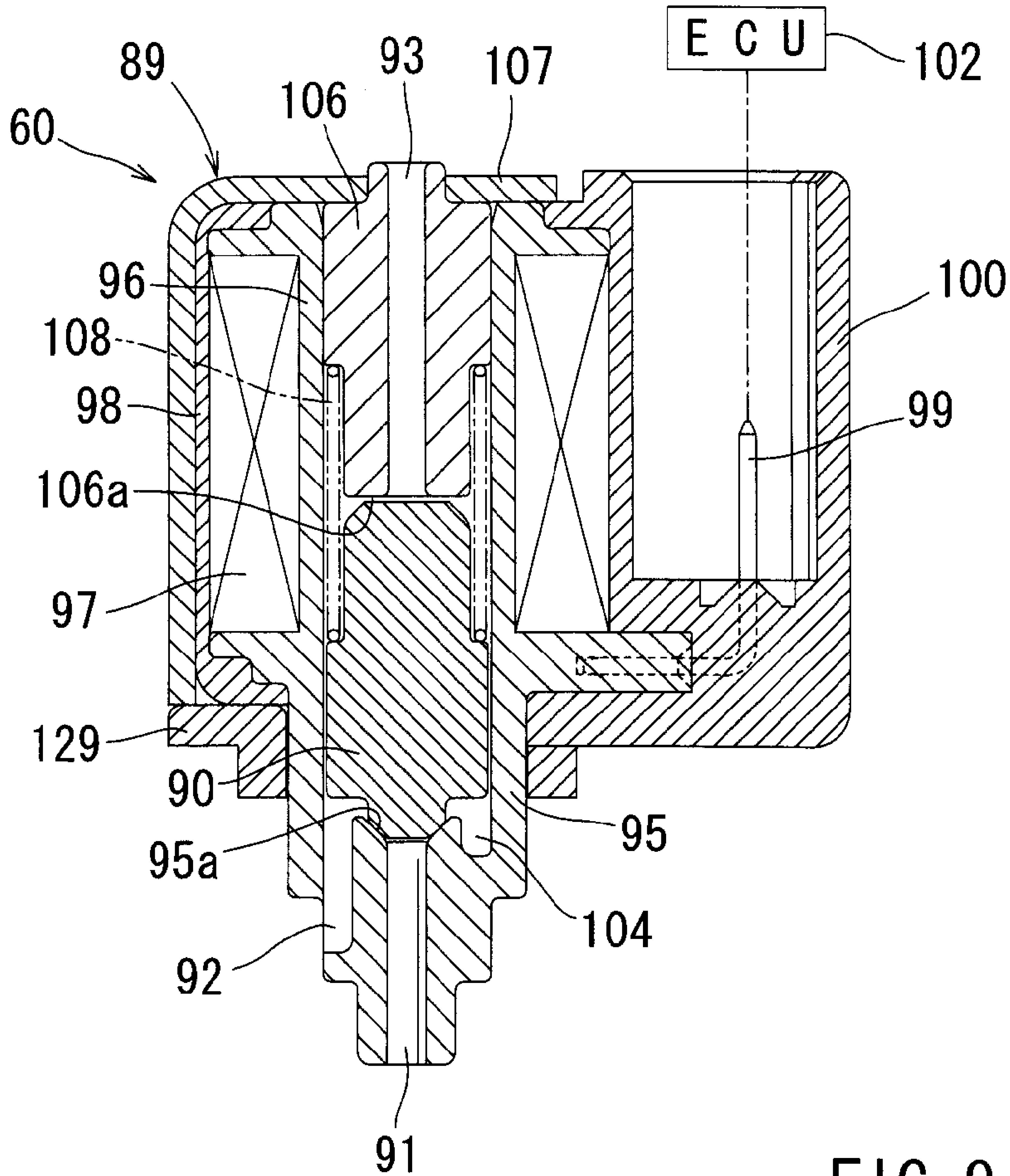
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FIG. 9

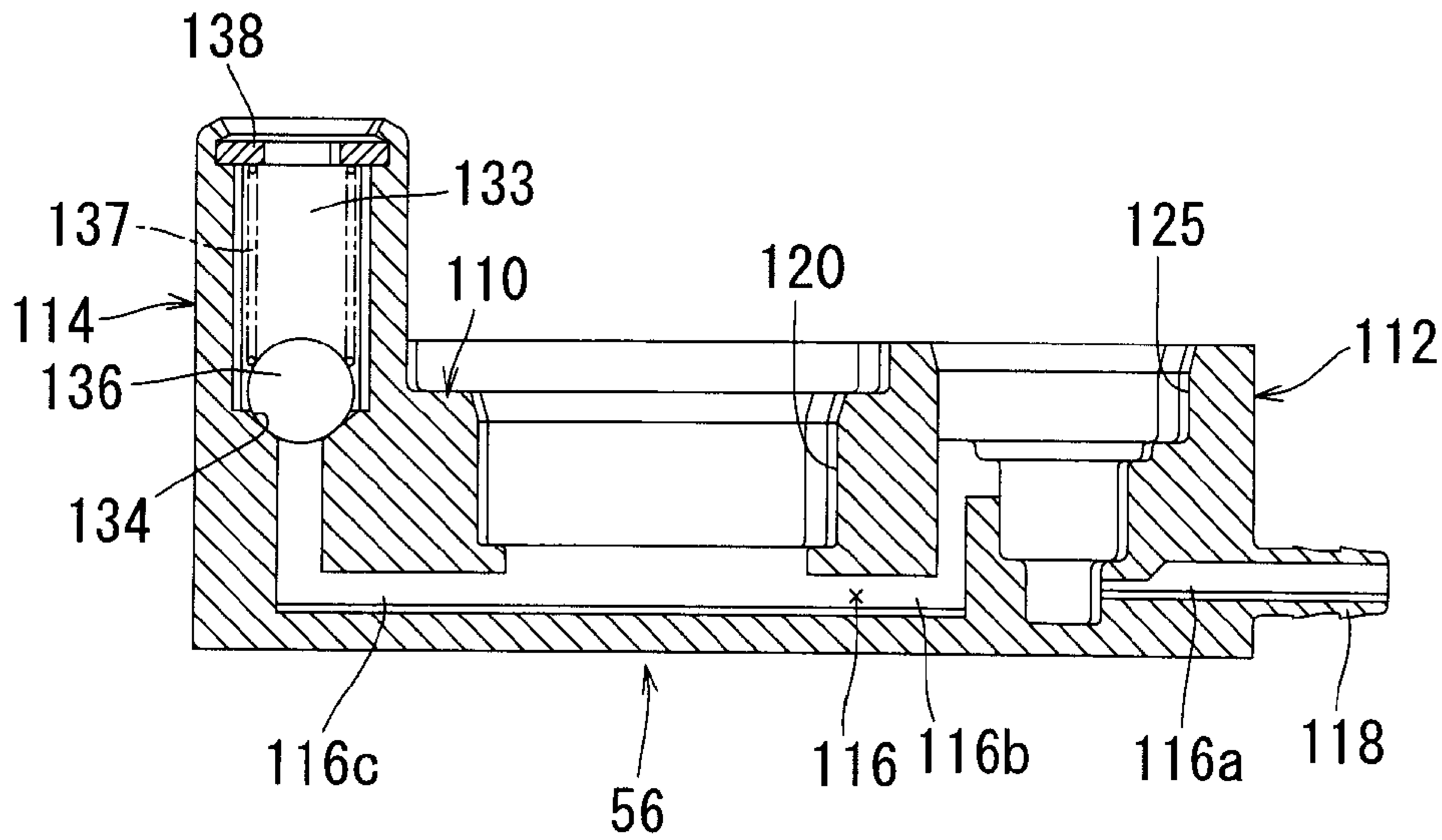
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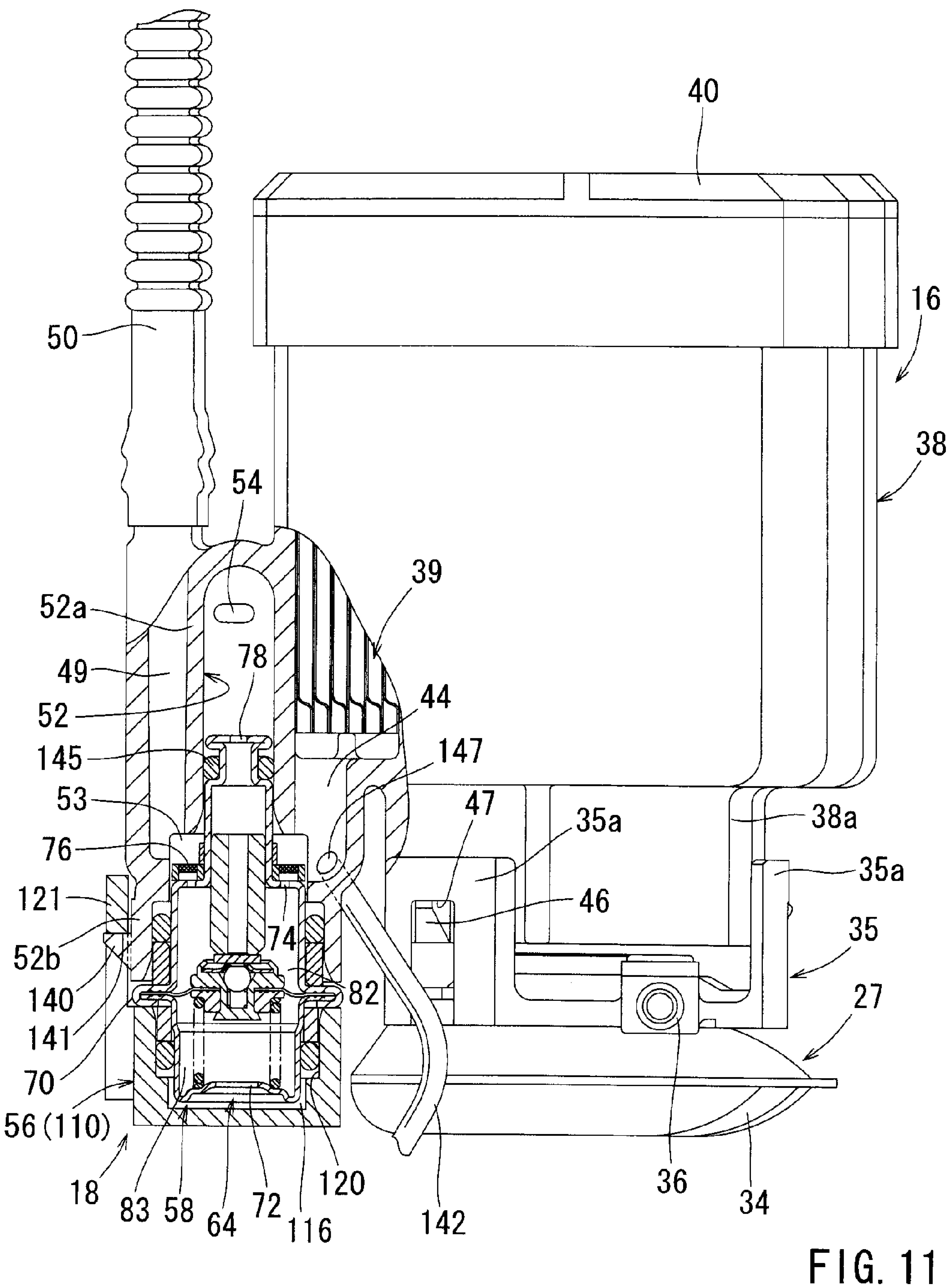
FIG. 10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52b
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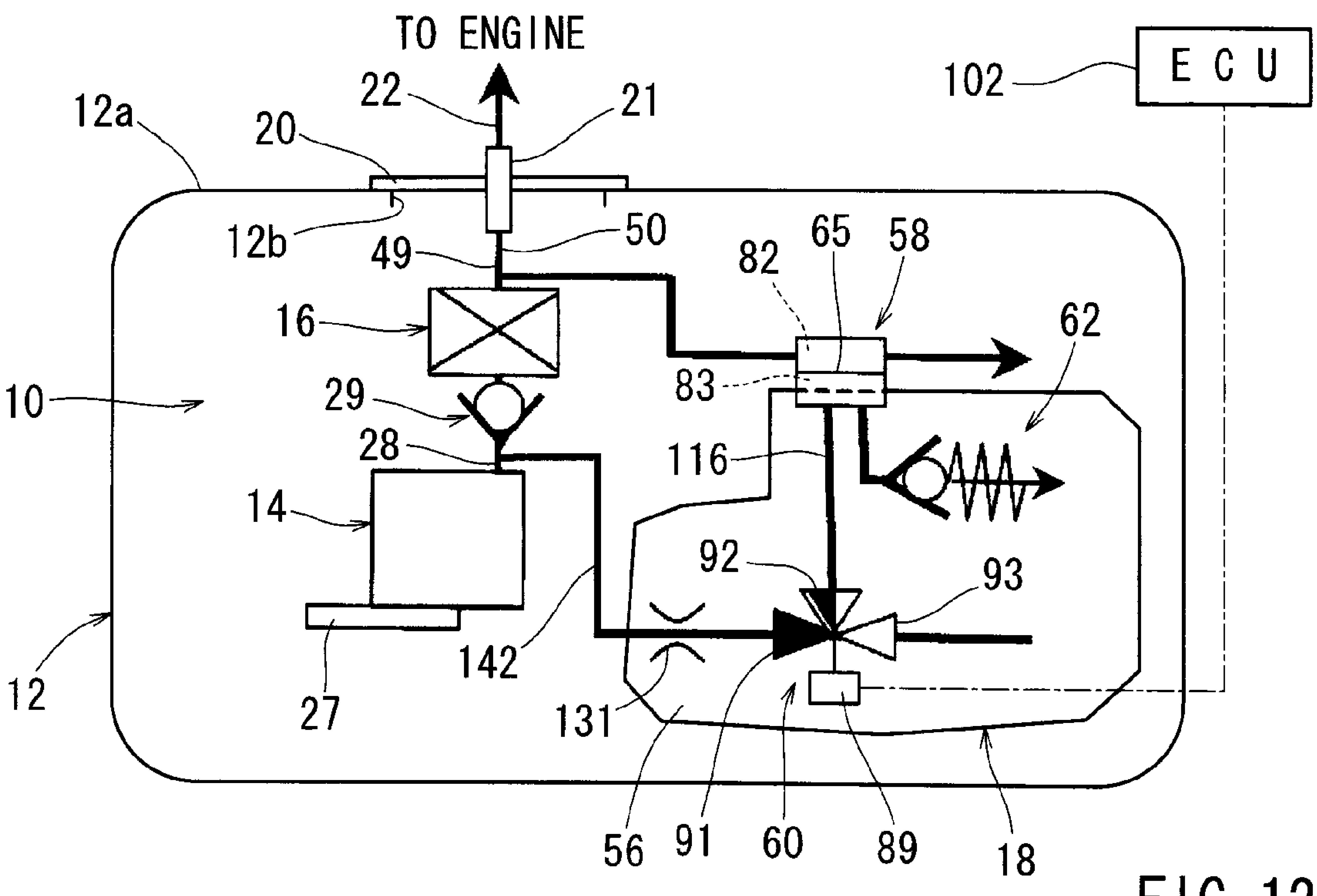
142
34

FIG. 11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12a
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E C U
12b
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58
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14
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93
142
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131
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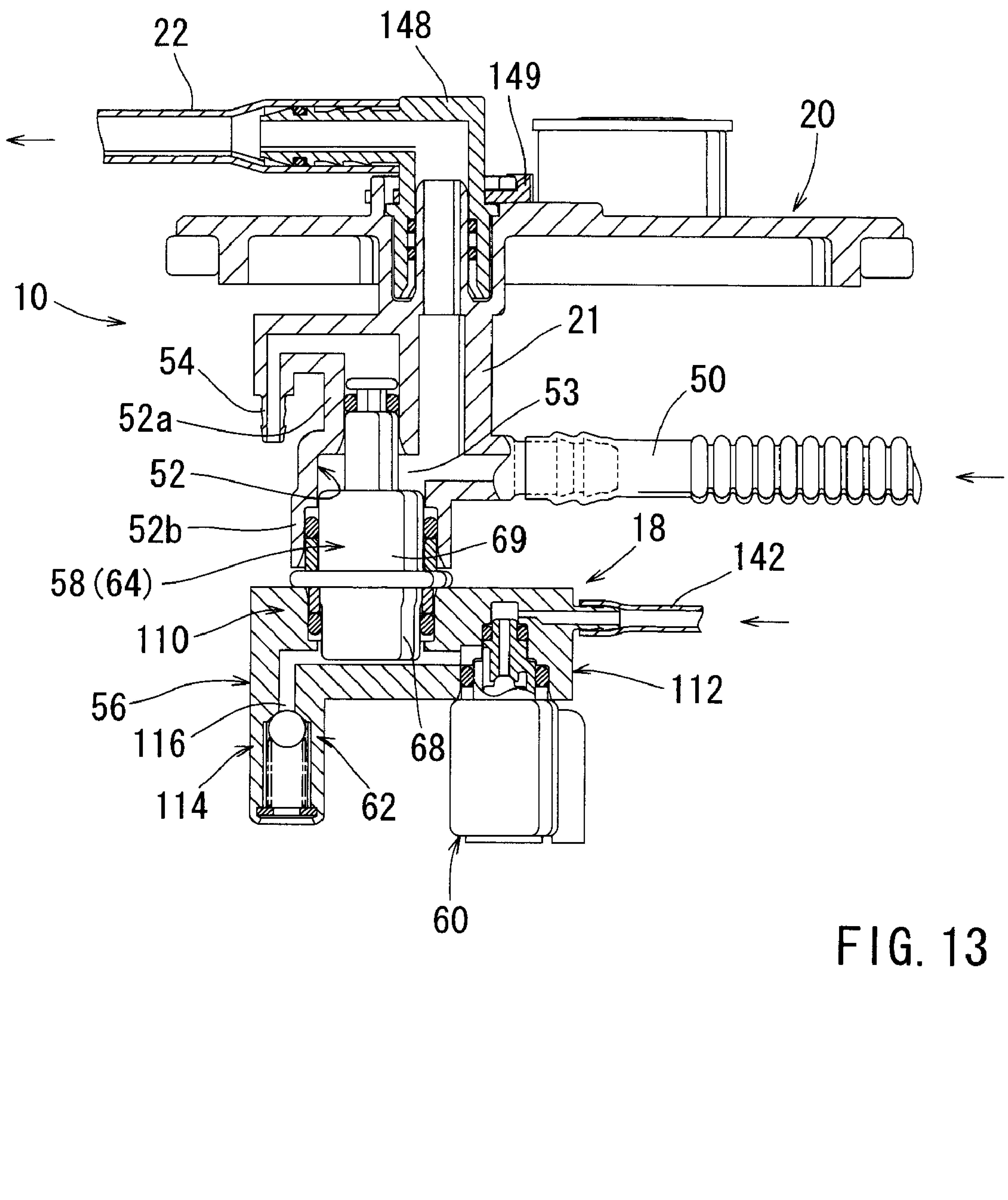
FIG. 12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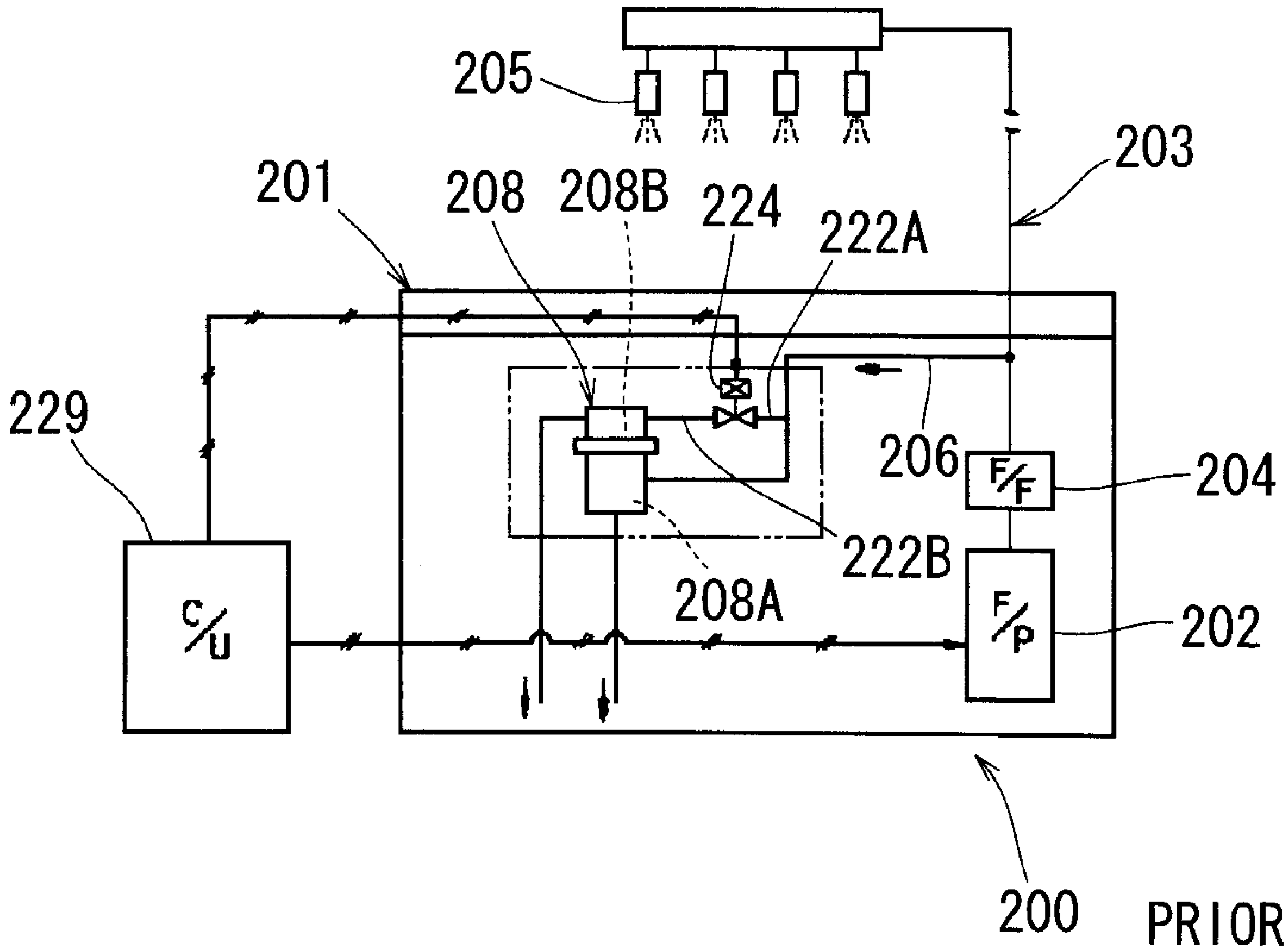
114
62
60

FIG. 13



PRIOR ART
FIG. 14

FUEL SUPPLY SYSTEMS

This application claims priority to Japanese patent application serial number 2008-212771, the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates to fuel supply systems mainly used for engines of vehicles.

A known fuel supply system will be described. FIG. **14** is a schematic structural view showing the known fuel supply system.

As shown in FIG. **14**, in a fuel supply system **200**, fuel in a fuel tank **201** is suctioned and pressurized due to a fuel pump **202**, and then is transported through a feeding pipe **203** and is injected from each of injection valves **205** toward a combustion chamber of an internal combustion engine (hereafter called "engine"). A reflux control valve **224** (also called "on-off valve") is opened and closed depending on control signals from a control unit **229** such that pressure of the fuel (hereafter called "fuel pressure") supplied to the injection valves **205** can be switched between two levels, i.e., high pressure level and low pressure level. That is, when the reflux control valve **224** is opened during, for example, engine starting, the fuel is introduced into a control pressure chamber **208**B of a pressure regulator **208**, and fuel pressure in the control pressure chamber **208**B increases. With this, fuel pressure in a pressure regulating chamber **208**A of the pressure regulator **208** is increased, and fuel pressure in the feeding pipe **203** communicating with the pressure regulating chamber **208**A is increased. This makes the pressure of fuel supplied to each injection valves **205** increase, so that atomization of injected fuel is enhanced, and startability of the engine is improved. In addition, when the reflux control valve **224** is closed after engine starting, introduction of fuel into the control pressure chamber **208**B of the pressure regulator **208** is inhibited, and the fuel pressure in the control pressure chamber **208**B decreases. With this, the fuel pressure in the pressure regulating chamber **208**A is decreased, and the fuel pressure in the feeding pipe **203** is decreased. This makes the pressure of the fuel supplied to the each injection valve **205** decrease, so that a load, for example, on the fuel pump **202** can be reduced. The known fuel supply system is disclosed in, for example, Japanese Laid-Open Patent Publication No. 2001-90624.

In the known fuel supply system **200** (refer to FIG. **14**), a fuel induction pipe **206** branched from the feeding pipe **203** is connected to the pressure regulating chamber **208**A of the pressure regulator **208**, and an upstream induction pipe **222**A branched from the fuel induction pipe **206** is connected to the reflux control valve **224** (in particular, valve chamber). The reflux control valve **224** (in particular, valve chamber) is connected with the control pressure chamber **208**B of the pressure regulator **208** via a downstream induction pipe **222**B. The upstream induction pipe **222**A and the downstream induction pipe **222**B form a fuel passage for control pressure (hereafter called fuel passage) to the control pressure chamber **208**B of the pressure regulator **208** and the reflux control valve **224**, and are composed of piping members such as hose or pipe. Accordingly, the number of piping members used for the fuel passage and the number of assembly steps must be increased, resulting complicating the piping work. In addition, complex piping arrangement causes decrease of assembly property of the pressure regulator **208** and the reflux control valve **224** and decrease of sealing performance depending on the assembly property.

Thus, there is a need in the art for an improved fuel supply system.

SUMMARY OF THE INVENTION

One aspect according to a fuel supply system of the present invention includes a fuel pump for supplying fuel in a fuel tank to an engine, a pressure regulator and a three-way valve disposed in a valve chamber. The pressure regulator includes a pressure regulating chamber and a control pressure chamber and adjusts fuel pressure in the pressure regulating chamber depending on fuel pressure in the control pressure chamber. A control pressure passage for flowing the fuel to the control pressure chamber and the valve chamber is defined in a unit case.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic structural view showing a fuel supply system according to one aspect of the invention;

FIG. **2** is a partially sectional front view of the fuel supply system;

FIG. **3** is a cross-sectional view along line III-III in FIG. **2**;

FIG. **4** is a cross-sectional view along line IV-IV in FIG. **2**;

FIG. **5** is a cross-sectional view of a fuel pump;

FIG. **6** is a cross-sectional view showing a part of a filter case;

FIG. **7** is a cross-sectional side view of a control pressure regulation unit;

FIG. **8** is a cross-sectional view of a pressure regulator;

FIG. **9** is a cross-sectional view of a three-way valve;

FIG. **10** is a cross-sectional view of a unit case;

FIG. **11** is a partially sectional front view of a fuel supply system according to another aspect;

FIG. **12** is a schematic structural view of a fuel supply system according to another aspect;

FIG. **13** is a partially sectional front view of a fuel supply system according to another aspect; and

FIG. **14** is a schematic structural view of a fuel supply system known in the prior art.

DETAILED DESCRIPTION OF THE INVENTION

Each of the additional features and teachings disclosed above and below may be utilized separately or in conjunction with other features and teachings to provide improved fuel supply systems. Representative examples of the present invention, which examples utilized many of these additional features and teachings both separately and in conjunction with one another, will now be described in detail with reference to the attached drawings. This detailed description is merely intended to teach a person of skilled in the art further details for practicing preferred aspects of the present teachings and is not intended to limit the scope of the invention. Only the claims define the scope of the claimed invention. Therefore, combinations of features and steps disclosed in the following detailed description may not be necessary to practice the invention in the broadest sense, and are instead taught merely to particularly describe representative examples of the invention. Moreover, various features of the representative examples and the dependent claims may be combined in ways that are not specifically enumerated in order to provide additional useful embodiments of the present teachings.

One embodiment of a fuel supply system according to the present invention includes a fuel tank for storing fuel, a fuel pump, a pressure regulator, a control device, a changeover valve and a passage forming member. The fuel pump supplies the fuel in the tank to an engine. The pressure regulator has a pressure regulating chamber and a control pressure chamber divided by a movable partition, adjusts a fuel pressure in the pressure regulation chamber depending on pressure in the control pressure chamber, and discharges redundant fuel in the pressure regulation chamber. The fuel introduced into the pressure regulation chamber is the pressurized fuel after pressurization due to the fuel pump, whereas the fuel introduced into the control pressure chamber is the fuel after pressurization or being pressurized due to the fuel pump. The changeover valve is disposed in a valve chamber and selectively switches between an introduction of fuel and an introduction of air to the control pressure chamber of the pressure regulator depending on control by the control device. The passage forming member forms a control pressure passage for feeding the fuel to the control pressure chamber of the pressure regulator and the valve chamber for the changeover valve.

According to the above fuel supply system, the fuel in the fuel tank is suctioned and pressurized due to the fuel pump, and then is adjusted to a predetermined fuel pressure by the pressure regulator and is supplied to the engine. In addition, the changeover valve is controlled by the control device, and it is selectively switched between the induction of fuel and the induction of air to the control pressure chamber of the pressure regulator in order to change fuel pressure supplied to the engine.

Here, the control pressure passage for flowing the fuel to the control pressure chamber of the pressure regulator and the valve chamber of the changeover valve is formed in the passage forming member. Therefore, it is able to reduce the number of parts and the number of assembly steps as for piping members such as hose and pipe used for the fuel passage connected to control pressure chamber of the pressure regulator and the changeover valve.

According to another embodiment, the passage forming member supports a portion of the pressure regulator, which includes the control pressure chamber. Therefore, the passage forming member can work as a support member for the portion of the pressure regulator.

According to another embodiment, the pressure regulator and the changeover valve are assembled to the passage forming member from the same direction. Therefore, it is able to improve assembly property of the pressure regulator and the changeover valve to the passage forming member.

According to another embodiment, a relief valve controlling the fuel pressure in the control pressure chamber of the pressure regulator to a predetermined pressure is provided in the control pressure passage of the passage forming member. Therefore, it is able to control the fuel pressure in the control pressure chamber of the pressure regulator at the predetermined pressure due to the relief valve. In addition, the relief valve is disposed in the control pressure passage of the passage forming member, so that it is able to omit some piping members such as hose or pipe forming the fuel passage for the relief valve and to simplify a piping arrangement as for the fuel passage.

According to another embodiment, the changeover valve, the pressure regulator and the relief valve are sequentially disposed in the control pressure passage from an upstream side to a downstream side. Therefore, the fuel flowing in the control pressure passage of the passage forming member sequentially passes through the changeover valve, the pressure regulator and the relief valve, and then flows out of control pressure passage. Thus, it is able to prevent or reduce accumulation of the fuel in the control pressure passage.

According to the other embodiment, at least two of the pressure regulator, the changeover valve and the relief valve are assembled to the passage forming member from the same direction. Therefore, it is able to improve assembly property of at least two of the pressure regulator, the changeover valve and the relief valve to the passage forming member.

Aspects of the invention will be described in reference to the drawings.

FIG. **1** is a schematic structural view showing a fuel supply system. FIG. **2** is a partially sectional front view. FIG. **3** is a cross-sectional view along line III-III in FIG. **2**. FIG. **4** is a cross-sectional view along line IV-IV in FIG. **2**.

As shown in FIG. **1**, a fuel supply system **10**, that can be mounted on a vehicle, supplies fuel (in a fuel tank **12**) to an engine (in particular, an injector). The fuel supply system **10** has a fuel pump **14** disposed in the fuel tank **12**, a fuel filter **16** and a control pressure regulation unit **18**. An opening **12*b*** formed in an upper plate **12*a*** of the fuel tank **12** is closed with a set plate **20**. The set plate **20** is provided with a fuel feeding pipe **21** communicating inside and outside of the fuel tank **12**. In addition, a fuel feeding passage **22** communicating with the engine (in particular, the injector) is connected with the fuel feeding pipe **21** outside the fuel tank **12**.

FIG. **5** is a cross-sectional view of fuel pump **14**, which can be In-tank fuel pump integrated with a motor, including an electric motor **24** and an impeller pump **25** attached to a lower end of the motor **24**. A fuel intake opening **26** for suctioning the fuel in the fuel tank **12** is formed at a lower side of the pump **25**. The fuel intake opening **26** is connected with a suction filter **27** for filtering the fuel suctioned from the fuel tank **12** (refer to FIG. **1**) into the fuel pump **14**. A fuel discharge opening **28** for discharging the fuel in the motor **24** is provided at an upper surface of the motor **24**. In addition, a check valve **29** preventing backflow of the fuel is provided in the fuel discharge opening **28** of the fuel pump **14**.

In the fuel pump **14**, when an impeller **30** of the pump **25** is rotated due to operation of the motor **24**, the fuel in the fuel tank **12** is suctioned and pressurized, and then is discharged into the motor **24**. The fuel discharged from the pump **25** into the motor **24** cools the inside of the motor **24**, lubricates and cleans a rotating portion in the motor during flowing upward in the motor **24**, and then is discharged from the fuel discharge opening **28**. A vapor jet **32** for discharging vapor (bubble caused by vaporization of the fuel), which is included in the fuel during pressurization, from a pump passage **31** is mounted on a lower side of the pump **25**. In addition, the vapor jet **32** corresponds to "vapor fuel discharge opening discharging the fuel including vapor (called "vapor fuel")" herein.

As shown in FIG. **2**, the suction filter **27** has a filter member **34** formed in a bag shape and an attachment **35** mounted on an upper surface of the filter material **34**. The attachment **35** is fitted with the lower surface of the pump **25** such that an inner space of the filter member **34** communicates with the fuel intake opening **26**. The attachment **35** is provided with a hose connecting port **36** communicating with the vapor jet **32** of the fuel pump (refer to FIG. **5**) and protruding forward (refer to FIG. **4**). Here, the attachment **35** is adapted to be attached to a lower side of a filter case **38** (described later).

As shown in FIG. **2**, the fuel filter **16** has the filter case **38** and a cylindrical tubular filter element **39** dividing an inner space of the case **38** into two chambers. An upper opening of the filter case **38** is closed with a filter cover **40**. The filter case **38** has a fuel inlet (not shown) communicating with one chamber and a fuel outlet **44** communicating with the other chamber (refer to FIG. **2**). The fuel pump **14** is supported such that the pump **14** passes through a central region of the filter case **38** (refer to FIG. **4**). In addition, the fuel inlet of the filter case **38** communicates with the fuel discharge opening **28** of the fuel pump **14** (refer to FIG. **5**).

The attachment **35** of the suction filter **27** is attached to the lower surface of the filter case **38**, due to (for example) snap fitting. With respect to such snap fitting, at least one engaging projection **46**, which is formed on an outer surface of a cylindrical tubular portion **38***a* protruding downwardly from a lower surface of the filter case **38**, and at least one engaging hole **47**, which is formed in attaching pieces **35***a* (two pieces are shown in FIG. **2**) of the attachment **35** engaging with the outer cylindrical surface of the filter case **38**, engage with each other due to elastic deformation of the attaching piece **35***a*.

As shown in FIG. **2**, a fuel discharge passage **49** communicating with the filter case **38** and extending upwardly is formed at a lower right portion of the filter case **38**. An upper end of the fuel discharge passage **49** and a lower end of the fuel feeding pipe **21** of the set plate **20** communicate with each other via a piping member **50** in the fuel tank **12** (refer to FIG. **1**).

FIG. **6** is a cross-sectional view showing the main part of the filter case. A regulator receiving recess **52** in a cylindrical tubular shape opening at a bottom portion and closing at a top portion is formed between the fuel outlet **44** and the fuel discharge passage **49** of the filter case **38**. The regulator receiving recess **52** is formed in the cylindrical tubular shape having two stepped portions. A communicating port **53**, which communicates with the fuel outlet **44** and the fuel discharge passage **49** are formed on right and left sides of an lower end portion of an upper cylindrical portion **52***a* defining the regulator receiving recess **52**. In addition, fuel ejection openings **54** radially (in a front and rear direction of a paper with respect to FIG. **6**) passing through the upper cylindrical portion **52***a* at front and rear sides of an upper end portion of the upper cylindrical portion **52***a*.

FIG. **7** is a sectional side view of the control pressure regulation unit. As shown in FIG. **7**, the control pressure regulation unit **18** has a unit case **56**, a pressure regulator **58**, a three-way valve **60** and a relief valve **62**.

FIG. **8** is a cross-sectional view showing the pressure regulator. As shown in FIG. **8**, the pressure regulator **58** is composed of a casing **64**, a diaphragm **65** and a valve **66**. The casing **64** is an outer shell of the pressure regulator **58** and is formed by engaging a case **68**, which is positioned at a side of a control pressure chamber (lower side) and is formed in a cylindrical tubular shape opening upwardly and closed at a bottom portion, and a case **69**, which is positioned at a side of a pressure regulating chamber (upper side) and is formed in a cylindrical tubular shape opening downwardly and closed at a top portion, due to swaging. Here, a flange **70** protruding from an outer circumferential surface of the casing **64** is formed due to swaging of both cases **68** and **69**.

A communicating hole **72** opens at a bottom wall of the case **68** positioned at the side of the control pressure chamber. In addition, the case **69** at the pressure regulating chamber side is formed in a cylindrical shape having two stepped portions. A fuel feed opening **74** is formed in a stepped wall connecting a small diameter cylindrical portion **69***a* and a large diameter cylindrical portion **69***b* of the case **69**. A ring-shape filter member **76** to be positioned on the stepped wall is fitted with the small diameter cylindrical portion **69***a* of the case **69**. The filter member **76** can filter the fuel discharged from inside of the case **69** through the fuel feed opening **74**. In addition, a fuel discharge hole **78** opens in an upper end wall of the case **69**. An upper portion of a valve seat **80** in a cylindrical tubular shape is fixed within the small diameter cylindrical portion **69***a* of the case **69** due to press fitting.

The diaphragm **65** is supported from both sides thereof between the cases **68** and **69** and divides an inner space of the casing **64** into the pressure regulating chamber **82** at the upper side and the control pressure chamber **83** at the lower side. The diaphragm **65** is formed from a rubber like elastic material, and thus has flexibility. The diaphragm **65** corresponds to "movable partition" herein. In addition, a central portion of the diaphragm **65** is engaged with a support member **85** at an upper side and a spring receiving portion **86** at a lower side due to swaging.

The valve **66** is movably supported on the support member **85**. When the valve **66** moves in an axial direction (vertical direction) due to flexural deformation of the diaphragm, a lower end of the valve seat **80** is opened and closed, so that communication between inside of the valve seat **80** and the pressure regulating chamber **82** can be allowed and blocked. Within the control pressure chamber **83**, a valve spring **87** made of a coil spring is disposed between the bottom wall of the case **68** at the side of the control pressure chamber and the spring receiving portion **86**. The valve spring **87** is biased in a direction that the valve **66** is seated on the valve seat **86**, i.e., valve closing direction.

When a fuel pressure for pressing against the diaphragm **65** in the pressure regulating chamber **82** is lower than a pressing force against the diaphragm **65**, that is elastic force of the valve spring **87** in the control pressure chamber **83**, the valve **66** is moved upwardly due to the elastic force of the valve spring **87** and is seated on the valve seat **80**. When the fuel pressure in the pressure regulating chamber **82** is higher than the elastic force of the valve spring **87**, the valve **66** is moved downwardly due to flexural deformation of the diaphragm **65** and is removed away from the valve seat **80**. This causes reduction of the fuel pressure in the pressure regulating chamber **82** to a predetermined value. In addition, when the fuel pressure in the pressure regulating chamber **82** reaches the predetermined value, the valve **66** is closed due to the elastic force of the valve spring **87**.

FIG. **9** is a cross-sectional view showing the three-way valve. As shown in FIG. **9**, the three-way valve **60** is an electrically-driven changeover valve and is configured such that communicating states and blocking states of a first port **91**, a second port **92** and a third port **93** can be changed by moving a plunger **90** in an axial direction (vertical direction in FIG. **9**) due to driving force of a solenoid portion **89**. The solenoid portion **89** is configured by winding a solenoid coil **97** around a bobbin portion **96** formed on an upper portion of a valve body in a cylindrical tubular shape. The bobbin portion **96** and the solenoid coil **97** are fitted with a resin portion **98**. A connector portion **100** in a socket shape surrounding a terminal **99** connected with the solenoid coil **97** is formed on the resin portion **98**. The connector portion **100** is configured to be connected with a power feeding connector in a plug shape (not shown) from above. Power distribution to the solenoid coil **97** is controlled depending on control signals from an electronic control unit (ECU) **102**. In addition, the three-way valve **60** corresponds to "changeover valve" herein.

A valve chamber **104** is formed in the valve body **95**. The first port **91** and the second port **92** communicating with the valve chamber **104** are formed on a lower end portion. The first port **91** passes through the valve body **95** in the axial direction (vertical direction in FIG. **9**) and opens at a lower surface of the valve body **95** and opens into the valve chamber **104**. A valve seat **95***a* is formed around an upper opening portion of the first port **91**. In addition, the second port **92** extends in the vertical direction and opens at an outer circumferential surface of the valve body **95** and opens into the valve chamber **104**.

A cylindrical member **106** in a cylindrical tubular shape is disposed within an upper portion of the bobbin portion **96** of the valve body **95**. The cylindrical member **106** is held by a magnetic plate **107** mounted on an upper surface of the valve body **95**. The third port **93** is defined by the cylindrical member **106** and passes through the cylindrical member **106** in the axial direction (vertical direction in FIG. **9**). A valve seat **106***a* is formed at a lower surface of the cylindrical member **106**. For convenience of explanation, the valve seat **106***a* is referred to as "upper valve seat **106***a*", whereas the valve seat **95***a* is referred to as "lower valve seat **95***a*". The plate **107** covers an outer circumferential surface of the resin portion **98**. A ring member **129** having magnetic properties and engaged with the valve body **95** is mounted on a lower surface of the resin portion **98**. A flange portion of the ring member **129** is attached to a lower portion of the plate **107** due to, for example, welding.

The plunger **90** is disposed in the valve chamber **104** of the valve body **95** so as to slidably move in the axial direction (vertical direction in FIG. **9**). In addition, a gap having a predetermined length is configured between an inner circumferential wall of the valve chamber **104** of the valve body **95** and an outer circumferential surface of the plunger **90**. The lower valve seat **95***a* and the upper valve seat **106***a* are selectively opened and closed due to vertical movement of the plunger **90**. A valve spring **108** made of a coil spring is disposed between the plunger **90** and the cylindrical member **106**. The valve spring **108** is biased in a direction that the plunger is seated on the lower valve seat **95***a*.

In the three-way valve **60**, when the solenoid coil **97** is not provided with the electric power (in an OFF state), the plunger **90** is pressed downwardly due to elastic force of the valve spring **108**. Thus, the plunger **90** is seated on the lower valve seat **95***a*, and the first port **91** is closed. In this state, the plunger **90** is removed away from the upper valve seat **106***a*, so that the third port **93** is opened. Therefore, the second port **92** and the third port **93** communicate with each other via the gap between the inner circumferential surface of the valve chamber **104** of the valve body **95** and the outer circumferential surface of the plunger **90**.

When the solenoid coil **97** is provided with the electric power (in an ON state), the plunger **90** is moved upwardly against the elastic force of the valve spring **108** due to magnetic force generated by provision of the electric power. Thus, the plunger **90** is seated on the upper valve seat **106***a*, and the third port **93** is closed. In this state, the plunger **90** is removed away from the lower valve seat **95***a*, so that the first port **91** is opened and communicates with the second port **92**.

The ECU **102** is a control unit composed of, for example, microcomputer. An input terminal of the ECU **102** is connected with a detecting device, e.g., a starting switch such as an ignition switch or a start switch of the engine. Whereas, an output terminal of the ECU **102** is connected with the solenoid coil **97** of the three-way valve **60**. In addition, the ECU **102** is configured to carry out on-off control of the solenoid coil **97** of the three-way valve **60** depending on operating state of the engine. For example, the ECU **102** is configured to put the solenoid coil **97** in the ON state during a predetermined period after starting process of the engine is started (the starting switch such as the ignition switch or the start switch is turned on), and to put the solenoid coil **97** in the OFF state after the elapse of the predetermined period. The ECU **102** corresponds to "control device" herein.

FIG. **10** is a cross-sectional view showing the unit case. As shown in FIG. **10**, the unit case **56** includes a regulator support portion **110**, a three-way valve support portion **112** formed at one side (for example, front side (right side in FIG. **10**)) of the regulator support portion **110**, and a relief valve support portion **114** formed on another side (for example, rear side (left side in FIG. **10**)) of the regulator support portion **110**. The support portions **110**, **112** and **114** are formed in a line in a front-back direction (right and left direction in FIG. **10**), and are close to each other. In addition, a control pressure passage **116** communicating with each of the support portions **110**, **112** and **114** is formed in the unit case **56**. One end (front end) of the control pressure passage **116** opens into a hose connecting port **118** formed on a front surface (right surface in FIG. **10**) of the unit case **56**. The other end of the control pressure passage **116** opens upwardly at the relief valve support portion **114**. In addition, the unit case **56** corresponds to "passage forming member" herein.

A regulator engaging recess **120** in a cylindrical tubular shape opening upwardly and having a bottom is formed in the regulator support portion **110**. The control pressure passage **116** passes through a bottom portion of the regulator engaging recess **120** in the front-back direction (right and left direction in FIG. **10**). As shown in FIG. **7**, the case **68** at the side of the control pressure chamber of the casing **64** in the pressure regulator **58** (refer to FIG. **8**) is fitted within the regulator engaging recess **120** from above. The flange portion **70** of the casing **64** is supported on an upper surface of the regulator support portion **110**. The communicating hole **72** of the pressure regulator **58** communicates with the control pressure passage **116**. An engaging piece **121** engaging with an outer circumference of a lower cylindrical portion **52***b* defining a regulator receiving recess **52** of the filter case **38** protrudes above the regulator support portion **110** (refer to FIG. **2**). An O-ring **122** and a ring-shape member **123** positioned above the O-ring **122** are disposed between an inner circumferential surface of the regulator engaging recess **120** and an outer circumferential surface of the case **68** at the side of the control pressure chamber (refer to FIG. **7**). In addition, the case **68** at the control pressure chamber side corresponds to "portion at a control pressure chamber side".

As shown in FIG. **10**, a valve engaging recess **125** in a cylindrical tubular shape opening upwardly and having a bottom is formed in the three-way valve support portion **112**. The valve engaging recess **125** is formed in a stepped cylindrical tubular shape such that the control pressure passage **116** passes through a bottom portion of the valve engaging recess **125** in the front-back direction (right and left direction in FIG. **10**). In particular, a downstream end of an upstream pathway **116***a* of the control pressure passage **116**, which communicates with the hose connecting port **118**, opens concentrically in a bottom surface of the valve engaging recess **125**. Whereas, an upstream end of a downstream pathway **116***b* of the control pressure passage **116**, which communicates with the regulator engaging recess **120**, opens in the inner circumferential surface of the valve engaging recess **125**.

As shown in FIG. **7**, a lower portion of the valve body **95** protruding below the ring member **129** of the three-way valve **60** (refer to FIG. **9**) is fitted within the valve engaging recess **125** from above. With this, the ring member **129** is supported on an upper surface of the three-way valve support portion **112**. The first port **91** of the three-way valve **60** communicates with the upstream pathway **116***a* of the control pressure passage **116**. The second port **92** of the three-way valve **60** communicates with the downstream pathway **116***b* of the control pressure passage **116**. A pair of O-rings **127** and **128** and a protrusion formed on the ring member **129** are disposed between the inner circumferential surface of the valve engaging recess **125** and the outer circumferential surface of the valve body **95**. A constricted portion **131** narrowing a downstream portion of the upstream pathway **116***a* is formed at an intermediate portion of the upstream pathway **116***a* of the control pressure passage **116**. The constricted portion **131** limits the amount of the fuel introduced into the control pressure chamber **83** of the pressure regulator **58** through the control pressure passage **116** to a predetermined amount.

As shown in FIG. **10**, a valve chamber **133** in a cylindrical tubular shape opening upwardly and having a bottom is formed in the relief valve support portion **114** of the unit case **56**. A downstream end of a pathway **116***c* of the control pressure passage, which communicates with the regulator engaging recess **120**, opens concentrically at a lower surface of the valve chamber **133**. A taper-shape valve seat **134** expanding upwardly is formed at the downstream end of the pathway **116***c*. A spherical valve **136**, a spring **137** made of a coil spring and a ring-shape stopper **138** are sequentially provided within the valve chamber from above. The spherical valve **136** can open and close the valve seat **134** due to its vertical movement. The spring **137** biases the spherical valve **136** in a closing direction (downwardly in FIG. **10**). The stopper **138** is fixed within an upper opening of the valve chamber **133** due to swaging and supports the spring **137** in a compressed state.

The control pressure regulation unit **18** (refer to FIG. **7**) is assembled on the filter case **38** (refer to FIG. **6**) of the fuel filter **16** as described below. That is, as shown in FIG. **2**, the regulator support portion **110** of the unit case **56** of the control pressure regulation unit **18** is attached to the lower cylindrical portion **52***b* of the regulator receiving recess **52** of the filter case **38** due to snap fitting. Here, such snap fitting is configured by an engaging projection **140** formed on an outer circumferential surface of the lower cylindrical portion **52***b* of the regulator receiving recess **52** of the filter case **38** and an engaged hole **141** formed in the engaging piece **121** of the regulator engaging recess **120**, which is engaged with the outer circumferential surface of the lower cylindrical portion **52***b*, and engaged with the engaging projection **140** due to elastic deformation of the engaging piece **121** (refer to FIG. **4**).

When the control pressure regulation unit **18** is assembled on the filter case **38**, the case **69** at the pressure regulating chamber side of the pressure regulator **58** is fitted within the regulator receiving recess **52** of the filter case **38**. Thus, as shown in FIG. **3**, the casing **64** of the pressure regulator **58** is supported from both sides thereof between the regulator receiving recess **52** of the filter case **38** and the regulator engaging recess **120** of the regulator support portion **110**, and the flange portion **70** of the casing **64** is supported from both sides thereof between the lower cylindrical portion **52***b* of the regulator receiving recess **52** and the regulator support portion **110**. In addition, the fuel feed opening **74** of the case **69** at the pressure regulating chamber side of the pressure regulator **58** communicates with the communicating port **53** of the filter case **38** via the filter member **76**. The fuel discharge hole **78** of the case **69** at the pressure regulating chamber side communicates with inside of the upper cylindrical portion **52***a* of the regulator receiving recess **52**.

As shown in FIG. **4**, the hose connecting port **36** of the suction filter **27** and the hose connecting port **118** of the unit case **56** communicate with each other via a fuel feed hose **142**. As shown in FIG. **3**, an O-ring **143** and a ring member **144** positioned below the O-ring **143** are disposed between the inner circumferential surface of the lower cylindrical portion **52***b* of the regulator receiving recess **52** and an outer circumferential surface of the large diameter cylindrical portion **69***b* of the pressure regulating chamber case **69**. An O-ring **145** is disposed between an inner circumferential surface of the upper cylindrical portion **52***a* of the regulator receiving recess **52** and an outer circumferential surface of the small diameter cylindrical portion of the case **69** at the pressure regulating chamber side. The fuel supply system **10** is disposed in the fuel tank **12** because, for example, the filter case **38** is supported on the set plate **20**.

Operation of the fuel supply system **10** will be described. In FIG. **1**, when the engine starts, the fuel pump **14** works so that the fuel in the fuel tank **12** is suctioned through the suction filter **27**, is pressurized due to the fuel pump **14**, and then is discharged from the fuel discharge opening **28** (refer to FIG. **5**). The pressurized fuel, which has been discharged, is filtered by the filter element **39** of the fuel filter **16** (refer to FIG. **2**), and then flows from the fuel outlet **44** of the filter case **38** (refer to FIG. **4**) to the communicating port **53** of the regulator receiving recess **52**. After that, the pressurized fuel is supplied to the engine, i.e., the injector through the fuel discharge passage **49**, the piping member **50**, the fuel feeding pipe **21** (refer to FIG. **1**) and fuel feeding passage **22**, and is injected into a combustion chamber of the engine from the injector. With this, a part of the fuel flowing through the communicating port **53** of the filter case **38** (refer to FIG. **2**) is introduced into the pressure regulating chamber **82** through the filter member **76** of the pressure regulator **58** and the fuel feed opening **74** (refer to FIG. **3**).

When the solenoid coil **97** of the three-way valve **60** is provided with the electric power due to the control signals from the ECU **102** with starting of engine operation, the first port **91** and the second port **92** communicate with each other, and the third port **93** is blocked. In this state, the fuel discharged from the vapor jet **32** of the fuel pump **14** (refer to FIG. **5**), that is partially pressurized fuel, is introduced from the hose connecting port **36** of the suction filter **27** (refer to FIG. **4**) into the control pressure passage **116** of the unit case **56** (refer to FIG. **3**) through the fuel feed hose **142**. When the fuel introduced into the control pressure passage **116** flows into the control pressure chamber **83** of the pressure regulator **58**, fuel pressure in the control pressure chamber **83** increases. At this time, the valve **66** of the pressure regulator **58** sits on the valve seat **80**, so that fuel pressure in the pressure regulating chamber **82** increases furthermore. When the fuel pressure in the pressure regulating chamber **82** of the pressure regulator **58** becomes higher than that of the control pressure chamber **83**, the diaphragm **65** is bent toward the control pressure chamber **83**, and the valve **66** is moved away from the valve seat **80**. Accordingly, the fuel in the pressure regulating chamber **82** is discharged into the upper cylindrical portion **52***a* of the regulator receiving recess **52** of the filter case **38** through the valve seat **80**, the small diameter cylindrical portion **69***a* of the case **69** at the control pressure chamber side, and the fuel discharge hole **78**. In addition, the fuel discharged into the upper cylindrical portion **52***a* is ejected into the fuel tank **12** through the fuel ejection opening **54**. When the fuel pressure in the pressure regulating chamber **82** decreases, the diaphragm **65** is bent toward the pressure regulating chamber **82**, and the valve **66** is seated on the valve seat **80**. In this way, the fuel pressure in the pressure regulating chamber **82**, that is the fuel pressure supplied to the engine, is adjusted to higher pressure than steady pressure, for example, to about 600 kPa.

As described previously, the fuel pressure supplied to the engine is adjusted to the pressure higher than the steady pressure due to the pressure regulator **58**, so that atomization of the fuel injected by the injector can be enhanced, and startability of the engine can be improved. The ON state of the three-way valve **60** is kept during a period from the time that the engine starts (the starting switch such as ignition switch or start switch is turned on) to the time that the predetermined period has been passed after completion of engine starting.

In addition, the pressure of the fuel introduced into the control pressure chamber **83** of the pressure regulator **58** is controlled to a predetermined pressure due to the relief valve **62**. That is, when the fuel pressure in the control pressure chamber **83** becomes higher than the elastic force of the spring **137**, the spherical valve **136** is moved away from the valve seat **134** against the elastic force of the spring **137**, and the fuel in the control pressure chamber **83** is released through the valve chamber **133**, so that the fuel pressure in the control pressure chamber **83** decreases to a predetermined pressure. When the fuel pressure in the control pressure chamber **83** reaches a predetermined pressure, the spherical valve **136** is seated on the valve seat **134** due to the elastic force of the spring **137**. Accordingly, the fuel pressure in the control pressure chamber **83** of the pressure regulator **58** is controlled to the predetermined pressure.

When the solenoid coil **97** of the three-way valve **60** is not provided with the electric power depending on the control signals from the ECU **102**, the first port **91** of the three-way valve **60** is blocked, whereas the second port **92** and the third port **93** communicate with each other. In this state, the fuel in the upper pathway **116***a* of the control pressure passage **116** of the unit case **56** is restricted to flow into the lower pathway **116***b*, i.e., the control pressure chamber **83** of the pressure regulator **58**. With this, air is introduced into the control pressure chamber **83**, that is, the control pressure chamber **83** is opened to the atmosphere. Therefore, pressure acting on the diaphragm **65** in the control pressure chamber **83** is caused by only the elastic force of the valve spring **87**. Accordingly, the fuel pressure in the pressure regulating chamber **82** of the pressure regulator **58**, that is, pressure of the fuel supplied to the engine is adjusted to the steady pressure, for example about 400 kPa.

As described previously, the pressure of the fuel supplied to the engine is adjusted to the steady pressure due to the pressure regulator **58** in order to reduce load on, for example, the fuel pump **14**. The ON state of the three-way valve **60** corresponds to "high pressure state" herein, and the OFF state of the three-way valve **60** corresponds to "steady pressure state" herein.

With respect to the fuel supply system **10** described previously, the fuel in the fuel tank **12** is suctioned into and pressurized by the fuel pump **14**, and then is adjusted to a predetermined pressure by the pressure regulator **58** and supplied to the engine. In addition, the three-way valve **60** is controlled due to the ECU **102**, and the fuel and the air are selectively switched for being supplied to the control pressure chamber **83** of the pressure regulator **58**, so that the pressure of the fuel supplied to the engine can be altered.

The control pressure passage **116** for feeding the fuel to the control pressure chamber **83** of the pressure regulator **58** and the valve chamber **104** of the three-way valve **60** is formed in a single member for forming passage, that is the unit case **56**. Therefore, the number of members and the number of assembly steps as for piping members such as hose or pipe used for the control pressure chamber **83** of the pressure regulator **58** and the three-way valve **60** can be reduced, and piping arrangement can be simplified. Thus, assembly property of the pressure regulator **58** and the three-way valve **60** to the unit case **56** and sealing property according to such assembly can be improved.

The controlled pressure in the control pressure chamber **83** of the pressure regulator **58** is more stabilized compared with a case that piping members such as hose or pipe are used, so that regulation ability of the pressure regulator **58** can be improved. The pressure regulator **58**, the three-way valve **60** and the relief valve **62** are disposed in a line in a front-back direction (right and left direction in FIG. **3**), so that the control pressure regulation unit **18** and consequently the fuel supply system **10** can be configured more compactly. The pressure regulator **58** and the three-way valve **60** can be located close to each other, so that volume of the fuel passage can be reduced, and the reactivity to pressure can be improved.

The unit case **56** supports the case **68** at the control pressure chamber side of the casing **64** of the pressure regulator **58**. In particular, the unit case **56** has a regulator support portion **110** supporting the case **68** at the control pressure chamber side of the casing **64** of the pressure regulator **58**. Therefore, the unit case **56** can also work as a member supporting the case **68** at the control pressure chamber side of the pressure regulator **58**.

The pressure regulator **58** and the three-way valve **60** are assembled to the unit case **56** from the same direction (from above in FIG. **3**). Therefore, assembly property of the pressure regulator **58** and the three-way valve **60** to the unit case **56** can be improved.

The relief valve **62** controlling the fuel pressure in the control pressure chamber **83** of the pressure regulator **58** to a predetermined pressure is provided in the control pressure passage **116** of the unit case **56** (FIG. **3**). Accordingly, the fuel pressure in the control pressure chamber **83** of the pressure regulator **58** can be controlled to a predetermined pressure due to the relief valve **62**. In addition, the relief valve **62** is provided in the control pressure passage **116** of the unit case **56**, so that piping members such as hose or pipe forming the fuel passage to the relief valve **62** can be omitted, and piping arrangement for the fuel passage can be simplified.

The three-way valve **60**, the pressure regulator **58** and the relief valve **62** are sequentially disposed in the control pressure passage **116** of the unit case **56** from an upstream side to a downstream side (FIG. **3**). Therefore, the fuel flowing in the control pressure passage **116** of the unit case **56** sequentially passes through the three-way valve **60**, the pressure regulator **58** and the relief valve **62**, and then is discharged from the control pressure passage **116**, so that the control pressure passage **116** does not have any dead-end portion. Accordingly, it is able to prevent or reduce stagnation, i.e., accumulation of the fuel in the control pressure passage **116**.

Three members, i.e., the pressure regulator **58**, the three-way valve **60** and the relief valve **62** are mounted on the unit case **56** from the same direction (from above in FIG. **3**). Therefore, assembly property of the pressure regulator **58**, the three-way valve **60** and the relief valve **62** to the unit case **56** can be improved. In addition, it is only necessary to configure such that at least two of the pressure regulator **58**, the three-way valve **60** and the relief valve **62** are assembled to the unit case **56** from the same direction.

Another aspect that is a modified version of the first will be described. Only modified portions will be described, and redundant explanation will be omitted. FIG. **11** is a partially sectional front view of the fuel supply system.

As shown in FIG. **11**, in this aspect, an upstream end of the fuel feed hose **142** in the first aspect (refer to FIG. **1**) is connected to a hose connecting hole **147** formed in a wall of the pathway between the fuel outlet **44** of the filter case **38** and the communicating port **53** instead of the hose connecting port **36** of the suction filter **27**. That is, it is configured that a part of the fuel discharged from the fuel outlet **44** of the filter case **38** (pressurized fuel) is introduced into the control pressure passage **116** of the unit case **56** through the fuel feed hose **142**.

A aspect will be described. This aspect is a modified version of the first aspect. Only modified portions will be described, and redundant explanation will be omitted. FIG. **12** is a schematic structural view showing the fuel supply system.

As shown in FIG. **12**, in this aspect, the upstream end of the fuel feed hose **142** in the first aspect (refer to FIG. **1**) is connected to the fuel discharge opening **28** of the fuel pump **14** instead of the hose connecting port **36** of the suction filter **27**. That is, it is configured that a part of the fuel discharged from the fuel discharge opening **28** of the fuel pump **14** (pressurized fuel) is introduced into the control pressure passage **116** of the unit case **56**.

Another aspect will be described. This aspect corresponds to the first aspect partially modified, so that only modified portions will be described, and redundant explanation will be omitted. FIG. **13** is a partially sectional front view showing the fuel supply system.

As shown in FIG. **13**, in this aspect, the regulator receiving recess **52** in the first aspect (refer to FIG. **3**) is formed in the set plate **20** instead of the filter case **38**. In addition, the fuel feeding pipe **21** is formed in an L-shape at a lower surface of the set plate **20**. A laterally extending end portion of the fuel feeding pipe **21** is connected with the piping member **50**. At an upper surface of the set plate **20**, an L-shape feed pipe **148** is rotatably connected to and upper end of the fuel feeding pipe **21** such that the feed pipe **148** is prevented from detaching from the upper end of the fuel feeding pipe **21** due to a clip **149**. This feed pipe **148** is connected with the fuel feeding passage **22**.

The regulator receiving recess **52** in a cylindrical tubular shape opening at a lower side is formed in one side portion (right side portion in FIG. **13**) of the fuel feeding pipe **21**. The communicating port **53** of the regulator receiving recess **52** communicates with the fuel feeding pipe **21**. In addition, an upper end of the upper cylindrical portion **52***a* of the regulator receiving recess **52** is formed in a reverse U-shape, and its lower end corresponds to the fuel ejection opening **54**.

In the unit case **56** of the control pressure regulation unit **18**, the three-way valve **112** and the relief valve support portion **114** are configured upside down compared with the first embodiment, and the two members, i.e., three-way valve **60** and the relief valve **62** are assembled to the unit case **56** from the same direction (from below in FIG. **13**). Therefore, it is able to improve assembly property of the three-way valve **60** and the relief valve **62** to the unit case **56**.

The present invention is not limited to the descriptions above, and can be modified without departing from the spirit and the scope of the invention. For example, the upstream end of the fuel feed hose **142** can be connected to a second fuel discharge opening formed in addition to the fuel discharge opening **28** of the fuel pump **14**. In addition, the upstream end of the fuel feed hose **142** can be connected to a second vapor jet formed in addition to the vapor jet **32** of the fuel pump **14**. That is, in a case that a part of the pressurized fuel or the partially pressurized fuel due to the fuel pump **14** is introduced into the control pressure chamber **83** of the pressure regulator **58**, the fuel can be introduced from any portion of the fuel pump **14**.

The invention claimed is:

1. A fuel supply system comprising:

a fuel tank for storing fuel;

a fuel pump supplying the fuel in the fuel tank to an engine;

a pressure regulator having a pressure regulating chamber and a control pressure chamber divided by a movable partition, adjusting fuel pressure in the pressure regulation chamber depending on pressure in the control pressure chamber, and discharging redundant fuel in the pressure regulation chamber, wherein the fuel introduced into the pressure regulation chamber is the pressurized fuel after pressurization due to the fuel pump, and wherein the fuel introduced into the control pressure chamber is the fuel after pressurization or being pressurized due to the fuel pump;

a control device;

a changeover valve disposed in a valve chamber and selectively switching between an introduction of fuel and an introduction of air to the control pressure chamber of the pressure regulator depending on control by the control device; and

a passage forming member forming a control pressure passage for feeding the fuel to the control pressure chamber of the pressure regulator and the valve chamber for the changeover valve.

2. The fuel supply system as in claim **1**, wherein the passage forming member supports a portion including the control pressure chamber of the pressure regulator.

3. The fuel supply system as in claim **2**, wherein the pressure regulator and the changeover valve are assembled to the passage forming member from the same direction.

4. The fuel supply system as in claim **3**, further comprising

a relief valve controlling the fuel pressure in the control pressure chamber of the pressure regulator to a predetermined pressure and disposed in the control pressure passage.

5. The fuel supply system as in claim **4**, wherein the pressure regulator, the changeover valve and the relief valve are sequentially disposed in the control pressure passage from an upstream side to a downstream side.

6. The fuel supply system as in claim **5**, wherein at least two of the pressure regulator, the changeover valve and the relief valve are assembled to the passage forming member from the same direction.

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